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Assessment of the 4VsW cod management unit following the 1985 fishery.

by

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ABSTRACT

Nominal catch in 1985 was slightly over 57,000 t, the highest since 1972, and 2,000 t in excess of the TAC. The 1977-1980 year-classes made up 75% of the biomass and 83% of the numbers in the 1985 catch. A comparison of the observed and projected catches indicated that the relative sizes of these important year-classes had been well predicted in the previous assessment. Analysis of geographic distribution of catch at age from research surveys and mean fish size in commercial catches indicated segregation of age groups. The estimated 5+ numbers per tow from the research surveys indicated an increasing trend since the early 1980s and current levels higher than any in the time series (1970 to present). The standardized commercial catch rate in 1985 was 45% higher than in 1984. These two time series of population estimates were used to calibrate sequential population analysis. Calibration indicated a 1985 terminal fishing mortality of .30. Catch projections based on these results indicated that if the 1986 TAC of 48,000 t is taken this would generate a fishing mortality of .26, and the projected $F_{0.1}$ catch in 1987 was found to be 38,000 t.

RESUME

En 1985, les prises nominales dépassaient légèrement 57 000 t, chiffre le plus élevé depuis 1972, et dépassaient de 2 000 t le TPA. Les classes d'âge 1977 à 1980 représentaient jusqu'à 75 % de la biomasse et 83 % du chiffre des prises de 1985. La comparaison entre les prises observées et projetées a indiqué que les dimensions relatives de ces importantes classes d'âge avaient été correctement calculées dans l'évaluation précédente. L'analyse de la distribution géographique des prises selon l'âge, déterminée d'après des relevés par navire de recherche, et la dimension moyenne des poissons dans les prises commerciales, ont indiqué une ségrégation des groupes d'âge. Les nombres estimés 5+ par trait, tels que déduits des relevés de recherche, ont indiqué qu'il existait une tendance ascendante depuis le début des années 1980 et que les niveaux actuels étaient plus élevés que dans toute la série temporelle (1970 à maintenant). En 1985, le taux normalisé de prises commerciales était de 45 % plus élevé qu'en 1984. Ces deux séries temporelles d'estimations des populations ont servi à étalonner l'analyse séquentielle de population. L'étalonnage a indiqué une mortalité par pêche de dernière année de 0,30 en 1985. Les projections relatives aux pêches, fondées sur ces résultats, ont indiqué que si l'on prenait le TPA de 1986 (48 000 t), on atteindrait une mortalité par pêche de 0,26, et qu'en 1987, les prises prévues d'après $F_{0,1}$ seraient de 38 000 t.

INTRODUCTION

Preliminary estimates of nominal catch for 1985 indicate an increase from 52,423 t in 1984 to 57,062 t in 1985 (Table 1). As has been the case since the extension of fisheries jurisdiction in 1977, Canada took well over 95% of the catch. Portugal was the only other nation to take a significant catch, 954 t under a national allocation of 1300 t.

Catches by Canadian vessels are taken mainly by otter trawlers (Table 2). There was a slight increase in the total otter trawler catch in 1985. Nominal catch by longliners increased substantially in 1985, however unconfirmed reports from the industry and Fisheries and Oceans (DFO) personnel indicate that this may be partially due to misreporting of catch from Div. 3NO. Nominal catch by seiners was down slightly while the miscellaneous catch increased, due mainly to an increase in pair trawler activity.

A map of the Scotian Shelf showing common fishing banks and NAFO Divisions is given in Figure 1. There has been a trend since 1980 for a greater proportion of the catch to be taken in Subdiv. 4Vs than Div. 4W (Figure 2). This trend is apparent for the three major gear components in the fishery. The otter trawler fishery is usually divided into spring and fall components. In the past both Subdiv. 4Vs and Div. 4W have been fished in the spring, but in 1984 and 1985 the spring fishery was almost exclusively concentrated in Subdiv. 4Vs. The fall fishery has traditionally been concentrated in Subdiv. 4Vs. The longliners, which fish mainly in the months of June to October, have increased activity in Subdiv. 4Vs (Table 2).

The 1985 TAC of 55,000 t was exceeded by 2,000 t. Recent Canadian allocations and associated catches are given in Table 3. The mobile gear less than 65' gear sector exceeded its 1985 quota by over 3,500 t mainly due to an influx of vessels based in southwest Nova Scotia in April and May (Sinclair and Gavaris 1985a). Despite the quota being exceeded in early June the fishery was allowed to continue with no quota transfer. Other gear sectors also exceeded their quotas, but by smaller amounts. Shortfalls in the foreign catch (Portugal) and fixed gear 65-100' resulted in the overall TAC being exceeded by only 2,000 t.

Maps of the distribution of catch per unit effort as recorded by Scotia-Fundy Region fisheries observers in 1980 and 1985 are shown in Figure 3. These are to augment similar maps presented in Gavaris and Sinclair (1985). In the January-June period of 1985 in Subdiv. 4Vs, the density of fish (CPUE) was higher and the distribution of fishing effort more extensive than in the 1980-84 period.

The advised $F_{0.1}$ catch level for 1986 is 36,000 t (CAFSAC Advisory Doc. 85/19). This represents a reduction over advice in the previous 4 years, however it is not due to a perceived reduction in stock size. Indeed, the projected exploitable stock size for 1985 and 1986 indicated that the stock was increasing in size. Rather, the reduced $F_{0.1}$ catch level was due to two factors, the estimation of a fully recruited F of .4, twice $F_{0.1}$; and a reduction in the estimated sizes of the 1979-1981 year-classes (Sinclair and Gavaris 1985b).

The Atlantic Groundfish Advisory Committee (AGAC) set the 1986 TAC at 48,000 t. This was because of evidence of high catch rates in 1985, that most other groundfish TAC's in the Scotia-Fundy Region had been recently reduced, and that industry was unwilling to accept a decreased TAC for a stock which appeared to be large and increasing in size.

CATCH AT AGE

No adjustments were made to previously estimated catch at age since no new sampling data were available and no significant change has been made to nominal catch statistics.

Sampling in 1985 was good for most gears. However, additional ageing material for the seiners would have been desirable. Only one age-length key was developed for this gear rather than the traditional two semi-annual keys. Catch in the second half of the year by this gear was low. Quarterly age-length keys were generated for otter trawlers and semi-annual keys for longliners. Examination of observer length frequencies for the Portuguese catch, which occurred in the fourth quarter, indicated close agreement with the Canadian otter trawlers in the same period. Thus, the Portuguese catch was included with the Canadian and catch at age was calculated using Canadian samples only. By-catch in the foreign fishery was less than 20 t in 1985, and since it was so small a separate age composition was not calculated. Length-weight parameters were obtained from an analysis of the 1985 summer groundfish survey collections.

Input data for generating the seven keys is given in Table 4. These accounted for 54,250 t or 95% of the total catch. The difference consisted of Canadian catch by miscellaneous gears and foreign by-catch. The APL workspace CATCH (Gavaris and Gavaris, 1983) (Anon. 1986) was used to calculate the catch at age. In the final calculation the individual keys were combined and the catches at age were increased to reflect the total landings. This assumes that the additional catch has the same age composition as the combined otter trawler, longline and seine. The 1985 estimated catch at age by gear and time period are given in Table 5 and the total catch, mean weight, mean length, standard error, and coefficients of variation are given in Table 6. These variance estimates are recognized to be minimum estimates because the variation in individual length frequency samples is not taken into account.

The 1985 catch was dominated by the 1977 to 1980 year-classes (ages 5 to 8) which accounted for 78% of the catch biomass and 83% of the numbers.

A comparison of the observed and projected 1985 catch at age, indicates close agreement for most ages (Figure 4). The observed catch of age 3 fish (1982 year-class) was very small compared to the projected. There was also a shortfall for the age 4 (1981 year-class). These differences may be due to a decrease in partial recruitment of these year-classes in 1985 or to an overestimation of their sizes. For the ages 5 and 6 (1980 and 1979 year-classes) slightly more fish were caught than projected.

Catch at age for ages 1 to 15 and 1970-85 is given in Table 7. There has been a noticable reduction in the catches of young fish in recent years. Specifically the 1985 catch at age 3 is the lowest in the time period while that of age 4 is the lowest since 1977. These are the 1982 and 1981 year-classes respectively. Mean commercial weight at age for the same ages and time period are given in Table 8. The 1985 mean weights were similar to those of 1984 but lower than in the recent past, an average of which was used in last year's catch projections.

Estimates of the coefficients of variation in catch-at-age data were available for the period 1983-85 (Table 9). These were used to obtain preliminary estimates of the variance in sequential population analysis (SPA) calculations (White, G.N., pers. comm.). Variance in catch-at-age for the period prior to 1983 was estimated by applying the 1983-85 average coefficients of variation to the catch-at-age estimates for the same time period. It is noted, however, that this probably underestimates the true variance due to the poor levels of sampling in the early and mid 1970's for this stock. These variance estimates were then used to estimate the variance of the integrated catch which would closely approximate that of SPA for the converged part of the SPA matrix. The estimated coefficients of variation of the integrated catch (Table 10) indicate values less than 10% for ages 1-10 followed by increases to 30% for age 15.

RESEARCH SURVEY RESULTS

Plots of mean catch per tow at age by 10' square summarized over the 16 year research vessel survey time series are given in Figure 5. At age 2 the highest catches were around Sable Island and on the Eastern Shoal of Banquereau Bank. Through ages 3, 4, and 5+ the distribution shifts away from the shallow banks to the mixed depth strata north of Banquereau. This pattern suggests the spatial segregation of age groups within the management unit.

Preliminary population estimates from the 1985 summer survey were given in Sinclair and Gavaris (1985a). Following complete editing of the cruise data the estimates were recalculated with only minor differences appearing. No conversion factors were applied to account for possible differences in fishing power of the three vessels involved in the surveys pending analysis of a comparative fishing experiment carried out in the fall of 1985 in accordance with recommendations of the Statistics, Sampling, and Surveys Subcommittee. The trend in total population numbers has been declining since 1982, however the 1982 estimate was very high due to 2 large catches of age 2 and 3 fish, the 1980 and 1979 year-classes (Table 11).

The survey time series was also calculated assuming the Delta distribution for the observed catches per tow. This is a special case for estimating the mean and variance of a random variable which has some zero observations and the distribution of non-zero observations is lognormal (Pennington 1983). The use of the Delta distribution leads to more efficient estimates of sample means than using arithemetic averages providing sample sizes are adequate (Smith, S.J. pers. comm.). Estimated mean catch per tow at age and the associated variances using the Delta distribution are shown in Table 12. Mean and variance were proportional. The coefficients of variation of the means indicate values in excess of 20% for most cells (Table 12). The mean values which have been considered anamoulous in the past (i.e. the 1973 age 2 and 3 and the 1982 age 2 and 3) also had extremely high coefficients of variation.

The trend in arithmetic and Delta 5+ mean numbers per tow are very similar (Figure 6). The plot indicates that the 1985 estimate was lower than the 1984, but higher than the 1983 estimate. This supports the conclusion of Sinclair and Gavaris (1985b) that the 1984 estimate was anomalously high. The agreement between the age 4 estimates was not as close (Figure 6). For several of the higher estimates (1972, 1973, 1981, 1982, 1983) the Delta estimates were lower. This is generally expected when a log transformation is used. Given the advantages of the Delta distribution it was decided to use it when calculating survey indices for calibration.

DISTRIBUTION OF MEAN SIZE IN COMMERCIAL CATCHES

Detailed sampling data from the commercial fishery are available from the Scotia Fundy Region Observer Program for the years 1978 to the present. At this time the 1980-1985 data series are completely edited and available for analysis. To investigate spatial segregation in the commercial fishery mean fish weights by sample were calculated. The distribution of mean weights was divided into quantiles and coded values of the quantiles were plotted by the start position of the tow (Figure 7). On Banquereau Bank, the main area of the fishery, all size groups were found. Size class 1(.2-1.4 kg) dominated the Middle Bank area. Size class 2 (1.5-1.8 kg) were found in the northeast fishery area (Misaine Bank). The area south of Sable Island and along the 100 m contour of southwest Banquereau Bank was dominated by size class 4 samples (greater than 2.3 kg). These patterns, with the exception of the last mentioned, were consistent across years. The occurrence of large fish on southwest Banquereau was evident only in the spring of 1985.

Thus, within the commercial fishery, spatial segregation by size is evident.

COMMERCIAL CATCH RATES

The preliminary 1985 catch and effort data for Scotia-Fundy and Newfoundland based otter trawlers and longliners were added to the 1965-1984 data set used last year (Gavaris and Sinclair 1985). These data were analyzed using the multiplicative catch rate standardization (Gavaris 1980), using the APL workspace STANDARD. All observations where either the catch or effort was less than 10 units were eliminated from the dataset because of bias due to truncation of small numbers. Following Gagne et al (1984) Canada-Maritimes otter trawler data prior to 1974 were not used because the individual catch rate trends of these gears did not reflect the trend in fishable biomass of the stock. The Canada Maritime otter trawl catch rates for 1978 and 1979 were not used due to suspected misreporting. The same seven extreme observations noted and eliminated by Gavaris and Sinclair (1985) were also eliminated from the current analysis.

The remaining data were analysed using country-gear-tonnage class combinations, division, months, and years as categories. Side otter trawlers (M) TC4 in 4Vs in January of 1965 were used as the standard. Following the initial run the residual pattern was examined and no obvious outliers were recognized.

It was observed by Sinclair and Gavaris (1985a) that catch rates reported by Maritimes stern otter trawlers TC4 and 5 were deflated in 1985 because of restrictive cod trip limits. Narrative reports from fisheries observers indicated that beginning in the late fall of 1984 most of the vessels were given 50,000 lbs trip limits for cod in Subdiv. 4Vs, accompanied by much larger limits on haddock, pollock and flounders. All of these species were actively fished in the same statistical unit area in 1985, a situation not previously observed. In the course of a trip the captain would often first fish for cod to fill the trip limit, then change locations and fish for other species. At the end of the trip, cod was often the main species caught in the unit area, and thus all the effort would be allocated to cod directed. The result was that the cod catch rates were artificially deflated. This did not occur with other vessel types fishing in the area.

Examination of the residuals associated with Canada Maritimes stern otter trawlers (OTB2) TC5 from the initial analysis indicated the effect of the bias in the 1985 data (Figure 8). There was a disproportionate number of negative residuals indicating that the reported catch rates were consistently less than expected given the catch rates of other gear classes. This is not a desirable situation given the underlying assumptions of the multiplicative model. It was concluded that the magnitude of this bias was unpredictable and therefore no attempt was made to correct the input data. Rather, these data were not used in subsequent analysis.

The analysis was run a second time using the reduced data set. The residual distribution was re-examined for outliers as were partial regression leverage plots for the last year (White and Gavaris 1983). No obvious outliers were found. The residuals for OTB2, TC5 did not show an undesirable trend. Examination of the residual distribution for side trawlers and selected months indicated some temporal trends (Figure 9). Recently the side trawler fleet has been reduced in size and this may have resulted in only the most efficient vessels remaining. However, at this time there is no clear reason to explain the observed trends and the effect of these on the standardized series is unclear. Further study of this problem is warranted.

The model explained 57% of the observed variance in catch rates and all variable categories were significant (Table 13). The regression coefficients are given in Table 14. The predicted catch rates and standardized effort are given in Table 15 and the catch rate trend with 90% confidence intervals is shown in Figure 10. The trend shows a large decline in catch rate in the late 1960s and early 1970s. There was an increase from 1975 to 1980, a levelling off, then a large rise (45%) in 1985. A plot of standardized fishing effort indicates a minimum effort level in 1977, followed by an increase to a level comparable to the late 1960s between 1979-1984 (Figure 11). The 1985 effort level was 25% lower than the 1984 level.

PARTIAL RECRUITMENT

Yearly fishing mortalities at age from an initial cohort analysis using the 1984 PR estimate from the last assessment (PR 84 Table 16) were examined for trends in partial recruitment (PR). As was concluded in the past 3 assessments of the stock there was a period of flat topped recruitment in the early and mid 1970s, followed by a period of dome shaped recruitment (1979-81), and recently recruitment appeared to be again flat topped.

PR for the recent period (82-84) was estimated by assuming full recruitment for ages 7-10, calculating a yearly fully recruited F weighted by population numbers, then estimating PR at partially recruited ages. Averages were calculated for all ages over the 3 years, and the average vector was adjusted so that the age 7-10 mean was equal to 1. This vector was re-introduced to another cohort analysis and the process was repeated until a stable vector was found. The resulting vector is given as PR 82-84 in Table 16. Age 6 was found to be fully recruited and there was little variation across ages 6-11. In subsequent analyses the PR for ages 7-15 was set to 1.0.

The significant feature of this new PR vector is that it indicates higher recruitment at age than what was used last year (PR 84) and what is apparent for the 1979-81 period (PR 79-81). This is contrary to what is expected given a mesh size increase in the fishery in 1982 (Sinclair and Gavaris 1985b).

YIELD PER RECRUIT

A Thompson and Bell yield per recruit analysis was performed using the current estimate of partial recruitment and mean weights at age for the period 1970-85.

Input parameters are:

AGE	WEIGHT AT AGE	PARTIAL RECRUITMENT
1	.091	.000
2	.395	.000
3	.661	.130
4	.994	.510
5	1.484	.870
6	2.081	1.000
7	2.785	1.000
8	3.653	1.000
9	4.401	1.000
10	5.505	1.000
11	6.382	1.000
12	7.357	1.000
13	8.510	1.000
14	8.803	1.000
15	9.991	1.000

Yield per recruit at F = .20 was estimated to be .622 kg, while at F_{MAX} = .33 it was .655 kg. $F_{0.1}$ was estimated to be .19.

SEQUENTIAL POPULATION ANALYSIS (SPA)

The catch at ages 1-15 and 1970-1985 were used in cohort analysis. Natural mortality was assumed to be .2. For calibrations F on the oldest age (15) were set to .3 rather than iterating. Preliminary SPA's indicated that this had a negligable effect on the calibration variables. The input partial recruitment used was PR 82-84 from Table 16 with age 7-15 values set to 1.00. The SPA was calibrated using mean population numbers age 5+ vs survey 5+ mean catch per tow (Delta mean), and exploitable biomass against catch per unit effort. Linear regression using least squares was used for calibration. The criteria used for choosing terminal F were the maximal correlation coefficient, the closeness of the intercept to the origin, and the minimal sum of the last 5 squared standardized residuals (standardized by the mean squared error).

A comparison of the estimated coefficients of variation of the mean catch per tow from the survey results (using the Delta distribution) and the coefficients of variation of the integrated catch at age (i.e. SPA) indicated that survey estimates were more variable than the SPA (5 to 10 times). Therefore it was considered appropriate to calculate calibration regressions which minimized the residuals around the more variable survey estimates. Thus the calibrations were done using the survey data as the dependent variable.

The slope and intercept parameters of the regressions were highly sensitive to the choice of terminal F since the most recent points were also the highest in the time series. The correlation coefficient was highest and the intercept was closest to the origin at F_t = .25 (Table 17). However, the sum of the last 5 squared standardized residuals was lowest at F_t = .35.

Exploitable biomass was estimated using mean population numbers, commercial weights at age, and PR at age for 3 time periods, 1970-78, 1979-81, 1982-85. These were calibrated with standardized catch per unit effort. The current estimate of PR for 1982-84 is higher than that used last year. The result was that the estimated exploitable biomass was higher causing these three points to be above the regression line. The correlation coefficient peaked between F_t = .25 and .30 and the intercept was closest to the origin at F_t = .40 (Table 18). The sum of the squared residuals did not give a clear pattern due to the position of the 1982-84 points. However, at F_t greater than .35 the correlation coefficient declines quickly.

In summary, the observed catch at age in 1985 compared favorably with that predicted indicating that the relative sizes of the major year-classes (1977-1980) were well estimated last year. The 1985 catch rates were expected to increase but not as much as observed. However, the 1985 CPUE may have been overestimated due to changing conditions in the fishery (eg. increased relative power of side trawlers). Based on the results of calibration and the comparison of observed and predicted events in the 1985 fishery a teminal F of .30 in 1985 was selected. This is consistent with recent levels of F in the SPA (.29 - .33 for 1982-84), and with the projected 1985 F = .35 at a catch of 55,000 t. The two calibration plots at F_t = .30 are given in Figure 12. Estimated beginning of the year population numbers, mean biomass, and fishing mortalities at age are given in Tables 19-21 respectively. For the final SPA F on the oldest ages was set equal to the weighted mean 7+ value for the year.

ASSESSMENT RESULTS

Recruitment

The method used to estimate PR is not sensitive to short term changes in this important factor. It has been demonstrated that the resource is spatially segregated by age (survey results Figure 5) and by size (commercial catch Figure 7). Thus the fishermen should be able to select the size and age of the catch by changing the location fished. Thus PR may change substantially just by the behaviour of the fishermen.

Using a 1985 F_t of .30 and the PR given above the estimated sizes of the 1981 and 1982 year-classes at age 1 were well below the smallest previously observed. The same condition was noted in the previous assessment. However, these two year-classes do not appear to be so small in the research survey results. Due to the lack of internal consistency along cohorts in the survey data it was concluded that survey estimates at ages 4 and younger could not be used for calibrating the sizes of the 1981 and 1982 year-classes. Rather, due to uncertainties in the estimated PR for these ages it was decided to increase the population estimates so that they would be approximately equal to the smallest previously observed (64 million at age 1 for the 1972 year-class). The PR required to give these estimates is given in the table on projection input.

Production

Production calculations were carried out using APL programs developed by Rivard (1982) using the FISH workspace. Total production in the early 1970's was due mainly to growth with recruitment production (age 3) being low (Figure 13). Simultaneously the catch was exceeding surplus production and this led to the decline in biomass in the mid 1970's. The recruitment of larger year-classes, a reduction of the catch of young fish in the foreign small mesh fishery, and a general reduction in the level of fishing mortality has occurred since the extension of fisheries jurisdiction. As a result surplus production has exceeded catch for the period 1976-1983, and population biomass has recovered to historic high levels. Recent declines in mean weight at age have contributed to a levelling off of growth production. With the current estimate of stock size, catches in 1984 and 1985 have slightly exceeded surplus production.

PROGNOSIS

Catch projections were made using the 1985 population size from the SPA and the 1985 catch at age. Weights at age in the commercial fishery showed a decreasing trend through the early 1980's. This is likely to be due to a change in the seasonal and geographic pattern of the fishery since this trend was not found in the research survey weights at age. The 1985 commercial weights at age were similar to those from 1984. Thus the 1985 weights were used for projections. The long term geometric mean recruitment (1958-present) for this stock is 107 million fish at age 1. Since 1970 there have only been three year-classes greater in size than this, the 1977 at 119 million, the 1978 at 113 million and the 1979 at 133 million. It was considered more appropriate to use the geometic mean for the 1969-1980 year-classes, namely 91 million fish as input values for the 1983-1985 year-classes in projections. The expected long term average yield at the F = .2 yield per recruit of .622 kg would be 57,000 t. Input data for projections are as follows:

Age	Number ($x10^{-3}$) 1985	Catch ($x10^{-3}$) 1985	Weight (kg)	PR
1	91000	0		0
2	74504	4	.635	.0002
3	42560	154	.701	.013
4	35427	2323	1.044	.250
5	40003	8353	1.456	.869
6	32722	7782	1.981	1.000
7	16613	3922	2.491	1.000
8	9420	2224	3.170	1.000
9	4143	978	3.933	1.000
10	1809	427	5.105	1.000
11	1161	274	6.368	1.000
12	712	168	6.14	1.000
13	275	65	9.935	1.000
14	80	19	11.167	1.000
15	27	16	11.255	1.000

If the 1986 TAC of 48,000 t is taken, which would generate a fishing mortality of .26, the projected $F_{0.1}$ = .2 catch in 1987 is 38,000 t. The projected $F_{0.1}$ catches in 1986 and 1987 are 38,000 t and 40,000 t. The projected catch at age in 1986 and 1987 under both scenarios is given in Table 22.

The implied fishable biomass in 1985 and that for 1986 and 1987 under the assumption that the 1986 TAC is taken are 200,000 t, 207,000 t, and 206,000 t. This suggests that catch rates will be stable and that the recent increasing trend in stock size has ended.

A summary of vital parameters estimated from the past 3 assessments of the stock are given below:

Population Year	F_t	Year-Class Size at Age 3 ($x10^6$) 1979	1980	1981	1982
1983	.35	111	112	(72)*	(72)*
1984	.40	81	69	43	(72)*
1985	.30	89	71	44	43

* assumed

Each estimate of F_t has been well above $F_{0.1}$. The major difference between 1983 and 1984 assessment results was the sizes of the 1979 and 1980 year-classes. Estimates for these year-classes in 1985 were consistent with those from 1984. However, the 1982 year-class estimate has been revised downward in 1985.

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Table 1. 4VsW cod nominal catches by country and NAFO Divisions.

YEAR	CANADA	FRANCE	PORTUGAL	SPAIN	USSR	OTHERS	TOTAL	SUBDIV. 4Vs	DIV. 4W	TAC
1958	17938	4577	1095	14857	-	124	38591	23790	14801	-
1959	20069	16378	8384	19999	-	1196	66026	47063	18963	-
1960	18389	1018	1720	29391	-	126	50645	27689	22956	-
1961	19697	3252	2321	40884	113	42	66309	34237	32072	-
1962	17579	2645	341	42146	2383	60	65154	26350	38804	-
1963	13144	72	617	44528	9505	307	68173	27566	40607	-
1964	14330	1010	-	39690	7133	1094	63257	25496	37761	-
1965	23104	536	88	39280	7856	122	70986	36713	34273	-
1966	17690	1494	-	43157	5473	711	68525	27177	41348	-
1967	18464	77	102	33934	1068	513	54158	26607	27551	-
1968	24888	225	-	50418	4865	32	80428	48781	31647	-
1969	14188	217	-	32305	2783	672	50165	22316	27849	-
1970	11818	420	296	41926	2521	453	57434	28639	28795	-
1971	17064	4	18	30864	4506	107	52563	24128	28435	-
1972	19987	495	856	28542	4646	7119	61645	36533	25112	-
1973	15929	922	849	30883	2918	2592	54093	23401	30692	60500
1974	10700	35	1464	27384	3097	1061	43741	19611	24130	60000
1975	9939	1867	546	15611	3041	1512	32517	11694	20823	60000
1976	9567	697	-	11090	1018	2035	24407	11553	12854	30000
1977	9890	68	-	-	97	335	10390	2873	7517	7000
1978	24642	437	-	57	218	51	25405	10357	15048	7000
1979	39219	18	-	2	683	108	40030	15393	24637	30000
1980	48821	17	5	5	338	66	49252	31378	17874	45000
1981	53053	-	-	-	630	35	53718	32107	21611	50000
1982	55675	-	-	-	45	34	55754	40110	15644	55600
1983	50898	-	1230	-	190	62	52380	33170	19210	64000
1984[1]	51981	-	303	-	110	29	52423	42474	9949	55000
1985	56090[2]	-	954[3]	-	9[3]	9[3]	57062	47830	9232	55000

[1] Preliminary NAFO
[2] Preliminary Scotia-Fundy and Newfoundland
[3] FLASH

Table 2. Canadian catch of 4VsW cod by gear and (sub) Division (from NAFO).

YEAR	4Vs					4W					4VsW				
	OTB	LL	SDN	MIS	TOTAL	OTB	LL	SDN	MIS	TOTAL	OTB	LL	SDN	MIS	TOTAL
1964	2056	42	2	-	2100	7324	708	88	4110	12230	9380	750	90	4110	14330
1965	7366	84	22	-	7472	10290	1339	159	3844	15632	17656	1423	181	3844	23104
1966	6374	143	14	-	6531	6614	1472	38	3035	11159	12988	1615	52	3035	17690
1967	6735	99	27	-	6861	6460	1453	71	3619	11603	13195	1552	98	3619	18464
1968	9501	48	18	-	9567	8360	1928	89	4944	15321	17861	1976	107	4944	24888
1969	3540	43	7	-	3590	4695	2647	13	3243	10598	8235	2690	20	3243	14188
1970	3054	21	1	-	3076	3602	3039	62	2039	8742	6656	3060	63	2039	11818
1971	5827	40	-	-	5867	4768	4173	26	2230	11197	10595	4213	26	2230	17064
1972	9856	115	4	-	9975	4732	3350	7	1923	10012	14588	3465	11	1923	19987
1973	6392	82	3	-	6477	4723	3173	20	1536	9452	11115	3255	23	1536	15929
1974	4644	56	-	-	4700	1335	2512	5	2148	6000	5979	2568	5	2148	10700
1975	1824	63	-	-	1887	3566	2558	11	1917	8052	5390	2621	11	1917	9939
1976	3755	42	-	-	3797	937	2289	14	2530	5770	4692	2331	14	2530	9567
1977	2751	50	4	-	2805	1873	3121	68	2023	7085	4624	3171	72	2023	9890
1978	9561	294	19	-	9874	7997	4321	839	1611	14768	17558	4615	858	1611	24642
1979	14853	438	86	-	15377	13784	5577	3245	1236	23842	28637	6015	3331	1236	39219
1980	28941	2116	321	-	31378	6298	6032	3440	1673	17443	35239	8148	3761	1673	48821
1981	27662	4274	171	-	32107	9148	7660	2433	1705	20946	36810	11934	2604	1705	53053
1982	32247	7069	794	-	40110	6352	5877	1943	1393	15565	38599	12946	2737	1393	55675
1983	26817	4475	671	-	31963	11280	4451	1936	1268	18935	38097	8926	2607	1268	50898
1984[1]	37149	4123	879	20	42171	3496	3067	2144	1103	9810	40645	7190	3023	1123	51981
1985[2]	38192	7390	718	567	46867	3010	2756	1230	2227	9223	41202	10146	1948	2794	56090

[1] Preliminary NAFO

[2] Preliminary Scotia-Fundy, preliminary Newfoundland

Table 3. 4VsW cod recent allocations and catches. Data were taken from final yearly quota reports. The catch figures from quota reports were close to (within 3%) but not exactly equal to the nominal catches reported in the Canadian statistics. All figures are metric tons.

Gear Sector	1982			1983			1984			1985		
	Initial quota	Final Quota	Catch	Initial Quota	Final Quota	Catch	Initial Quota	Final Quota	Catch	Initial Quota	Final Quota	Catch
Vessels >100'	33950	36200	34926	39000	40500	36015	33550	38350	38275	34850	34850	34642
MG 65-100'	500	750	858	850	850	1218	730	1630	1360	730	1230	1481
FG 65-100'	1050	1280	1433	1250	1250	649	1070	870	470	1070	370	87
MG <65'	6500	6700	6546	7400	7400	3894	6340	4640	4399	6340	6340	9877
FG <65'	8000	10700	11735	12500	12500	9394	10710	8210	7635	10710	10910	11558
Canadian	50000	55600	-	61000	62500	-	52400	53700	-	53700	53700	-

Table 4. Data used to generate 1985 age length keys for 4VsW Cod.

Key	Gear	Period Covered	Length-weight Coeff. a	b	No. Measured	No. aged	Catch
1	Otter Trawl	Jan-Mar	.0088	3.006	7284	775	11009
2	Otter Trawl	Apr-June	.0088	3.006	9590	350	15780
3	Otter Trawl	July-Sept	.0088	3.006	2882	284	5640
4	Otter Trawl	Oct-Dec	.0088	3.006	5713	340	9727
5	Longline	Jan-June	.0088	3.006	3319	380	3588
6	Longline	July-Dec	.0088	3.006	2244	372	6558
7	Seines	Jan-Dec	.0088	3.006	2008	148	1948
	TOTAL						54,250

Table 5. 4VsW cod catch at age ('000) by key in 1985.

	OTB				LL		SDN
AGE	Q1	Q2	Q3	Q4	Q1-2	Q3-4	Q1-4
1	-	-	-	-	-	-	-
2	-	-	-	1	-	3	-
3	59	4	13	48	-	13	10
4	339	604	297	678	1	100	191
5	1254	2473	1438	1871	119	347	439
6	1478	2769	875	1413	111	482	269
7	1084	1068	391	439	174	343	230
8	664	551	107	235	164	319	75
9	379	164	27	110	123	106	22
10	134	51	10	58	66	87	1
11	63	35	5	24	74	60	1
12	48	27	1	5	40	37	1
13	3	3	-	-	19	36	-
14	2	1	-	-	9	7	-
15	1	-	-	-	5	9	-
16+	2	2	-	-	10	1	-

Table 6. 1985 catch at age ('000) for 4VsW cod with mean weights (kg), mean lengths (cm), and standard error.

	AVERAGE		CATCH		
AGE	WEIGHT	LENGTH	MEAN	STD. ERR.	C. V.
2	0.635	40.613	4	2.07	0.50
3	0.701	42.464	154	24.91	0.16
4	1.044	48.443	2323	183.08	0.08
5	1.456	54.017	8353	342.44	0.04
6	1.981	59.797	7782	357.70	0.05
7	2.491	64.398	3922	237.36	0.06
8	3.170	69.545	2224	151.91	0.07
9	3.933	74.601	978	80.72	0.08
10	5.105	80.897	427	48.27	0.11
11	6.368	86.876	274	31.74	0.12
12	6.121	84.496	168	32.57	0.19
13	9.935	102.544	65	12.05	0.19
14	11.167	106.338	19	5.55	0.29
15	11.255	107.085	16	6.03	0.37
16+	14.414	115.326	17	3.85	0.23

Table 7.

4VSW COD CATCH AT AGE 1/ 5/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	1293	2311	2383	1418	1482	1792	728	2	177	12	31	3	5	0	0	0
2	8631	15218	17738	12142	8451	9979	4061	24	153	81	152	348	149	0	2	4
3	8686	12582	14227	14881	12885	9485	3587	386	1004	1629	2034	3742	2500	3048	421	154
4	14802	9146	13361	7507	9947	4341	3713	1073	3650	6164	5119	9724	7664	8251	6210	2323
5	13673	8809	9661	9755	7130	4549	4818	1559	4621	9145	7112	7276	9953	7368	9371	8353
6	4539	10262	8780	3823	2766	2594	2412	871	2441	4871	6147	4852	3449	5967	6113	7782
7	1942	5160	3432	2996	944	2627	1426	501	768	1162	2929	2991	2408	1938	4102	3922
8	759	1849	1919	3724	1323	612	611	220	213	371	1066	1455	1273	999	1294	2224
9	236	496	358	1166	413	497	184	128	112	76	319	393	674	576	569	978
10	72	114	393	273	369	660	49	35	80	23	88	126	304	229	293	427
11	137	131	79	299	15	153	22	44	26	10	47	62	156	140	149	274
12	56	72	2	3	5	126	107	55	28	5	26	32	67	50	61	168
13	9	98	37	7	0	36	1	11	26	4	4	21	57	22	35	65
14	12	12	0	5	0	9	4	3	9	1	1	2	51	16	17	19
15	4	51	1	5	0	9	1	2	4	0	4	6	19	6	2	16
1+	55051	66311	72371	58004	45730	37469	21724	4914	13312	23554	25079	31033	28728	28610	28639	26709
2+	53758	64000	69988	56586	44248	35677	20996	4912	13135	23541	25048	31030	28723	28610	28639	26709
3+	45127	48782	52250	44444	35797	25698	16935	4888	12982	23460	24896	30682	28574	28610	28637	26705
4+	36241	36200	38023	29563	22912	16213	13348	4502	11978	21831	22862	26940	26074	25562	28216	26551
5+	21439	27054	24662	22056	12965	11872	9635	3429	8328	15666	17743	17216	18409	17311	22006	24228
6+	7766	18245	15001	12301	5835	7323	4817	1870	3707	6522	10631	9940	8457	9943	12635	15875

Table_8.

4VSW COD COMMERCIAL WEIGHTS AT AGE 1/ 5/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	0.020	0.010	0.050	0.080	0.130	0.100	0.100	0.100	0.200	0.000	0.000	0.000	0.000	0.120	0.000	0.000
2	0.150	0.110	0.180	0.220	0.330	0.270	0.280	0.280	0.620	0.530	0.570	0.616	0.581	0.390	0.559	0.635
3	0.450	0.320	0.440	0.450	0.620	0.530	0.570	0.810	0.950	0.760	0.800	0.833	0.805	0.807	0.724	0.701
4	0.910	0.640	0.810	0.790	1.020	0.890	0.960	1.090	1.250	1.060	1.150	1.139	1.073	1.082	0.999	1.044
5	1.500	1.070	1.290	1.210	1.530	1.340	1.460	1.670	1.680	1.700	1.600	1.693	1.580	1.549	1.422	1.456
6	2.190	1.560	1.850	1.720	2.130	1.870	2.030	2.360	2.470	2.390	2.210	2.133	2.393	2.100	1.911	1.981
7	2.940	2.090	2.480	2.280	2.820	2.470	2.660	3.170	3.610	3.130	3.080	2.965	2.779	3.103	2.488	2.491
8	3.730	2.650	3.140	2.900	3.580	3.120	3.350	4.580	5.230	3.710	4.310	3.941	4.074	3.529	3.437	3.170
9	4.510	3.210	3.830	3.540	4.410	3.810	4.070	4.140	5.590	4.770	5.260	5.698	5.492	4.378	3.776	3.933
10	5.280	3.750	4.520	4.220	5.280	4.530	4.800	5.330	6.540	6.840	6.920	7.163	7.078	5.763	4.964	5.105
11	6.020	4.280	5.200	4.900	6.190	5.270	5.550	4.650	7.920	7.960	7.560	7.673	8.743	6.988	6.837	6.368
12	6.710	4.770	5.870	5.590	7.130	6.010	6.290	4.910	9.210	9.410	10.190	9.261	9.097	9.041	8.098	6.121
13	7.360	5.230	6.520	6.280	8.090	6.760	7.020	7.140	10.400	10.630	7.920	11.868	11.428	10.626	8.945	9.935
14	7.950	5.650	7.140	6.960	9.050	7.510	7.740	8.590	9.750	10.030	8.130	8.654	10.589	11.715	10.230	11.167
15	8.490	6.040	7.730	7.620	10.010	8.240	8.430	10.600	8.680	11.450	14.450	9.836	12.484	12.693	11.849	11.255

TABLE 9: COEFFICIENTS OF VARIATION
OF CATCH AT AGE FOR 4VsW COD.

	83	84	85
1	.400	.400	.400
2	.400	.400	.400
3	.068	.130	.162
4	.037	.038	.079
5	.037	.033	.041
6	.036	.041	.046
7	.054	.044	.061
8	.060	.063	.068
9	.070	.095	.083
10	.103	.123	.113
11	.120	.103	.116
12	.160	.122	.194
13	.213	.156	.185
14	.250	.186	.293
15	.289	.500	.375

TABLE 10: 4VsW COD COEFFICIENTS OF VARIATION FOR INTEGRATED CATCH.

	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85
1	.084	.096	.089	.072	.068	.031	.018	.018	.018	.021	.021	.024	.064	.145	.362	.362
2	.047	.085	.098	.091	.073	.069	.030	.018	.018	.018	.021	.021	.024	.064	.145	.362
3	.027	.029	.038	.042	.044	.036	.020	.018	.018	.018	.018	.021	.021	.024	.064	.146
4	.020	.020	.021	.020	.024	.020	.019	.019	.018	.018	.019	.018	.021	.021	.026	.071
5	.020	.020	.022	.021	.021	.021	.021	.021	.020	.019	.020	.020	.020	.024	.026	.037
6	.024	.025	.025	.026	.026	.025	.026	.025	.024	.024	.023	.024	.026	.024	.032	.042
7	.032	.030	.033	.032	.033	.035	.034	.035	.030	.030	.031	.030	.032	.034	.034	.055
8	.040	.042	.038	.044	.041	.046	.046	.047	.047	.038	.037	.040	.038	.044	.047	.062
9	.050	.051	.057	.050	.063	.056	.076	.072	.062	.059	.047	.049	.055	.051	.066	.075
10	.074	.067	.066	.078	.064	.083	.066	.136	.093	.079	.067	.059	.062	.078	.076	.102
11	.073	.093	.088	.086	.121	.078	.088	.083	.180	.122	.085	.081	.071	.076	.109	.105
12	.118	.104	.220	.167	.130	.132	.118	.103	.124	.257	.129	.106	.103	.100	.106	.175
13	.143	.158	.147	.238	.198	.142	.212	.138	.146	.228	.286	.155	.133	.147	.136	.168
14	.296	.202	.351	.220	.351	.198	.191	.233	.220	.295	.310	.323	.195	.205	.198	.265
15	.351	.351	.351	.351	.351	.351	.351	.351	.351	.351	.351	.351	.351	.261	.452	.339

Table 11.

4VSW COD RV POPULATION AT AGE 1/ 5/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
0	0	0	0	0	0	0	0	0	174	1017	50	74	9	57	200	0
1	1478	1539	6210	6430	5174	3372	2242	808	3033	1213	690	4589	2633	39572	1165	3697
2	16388	7680	9674	43907	32961	8412	14066	10145	13065	10612	7064	12770	226028	37813	20874	4834
3	5250	35664	11881	69024	19246	13000	16098	26372	31245	16044	18488	18936	188892	120818	36823	22643
4	7714	8027	31536	56081	5623	6171	10187	17059	34205	16595	10260	30753	65976	48451	54858	27478
5	3742	15803	5812	22484	2017	2959	6621	11353	9461	18075	17365	12057	14624	24808	37171	26772
6	1228	5775	5989	1870	2244	675	1264	4893	3490	9053	12099	8570	8020	11398	17253	14701
7	1532	3459	1621	2907	372	867	656	1081	889	2696	4794	4404	4325	2611	11861	7358
8	466	1475	547	901	463	235	1308	878	185	1009	1302	1553	1850	1444	1170	2896
9	104	638	495	431	224	433	0	244	90	411	338	533	413	395	955	1391
10	249	70	153	514	161	23	929	0	79	83	265	650	419	222	284	330
11	209	137	0	166	63	0	38	161	0	45	93	163	226	64	674	319
12	101	58	0	0	59	68	0	62	79	5	0	74	0	29	17	610
0+	38461	80325	73918	204715	68607	36215	53409	73056	95995	76858	72808	95126	513615	287682	183325	113029
1+	38461	80325	73918	204715	68607	36215	53409	73056	95821	75841	72758	95052	513606	287625	183125	113029
2+	36983	78786	67708	198285	63433	32843	51167	72248	92788	74628	72068	90463	510973	248053	181960	109332
3+	20595	71106	58034	154378	30472	24431	37101	62103	79723	64016	65004	77693	284945	210240	161066	104498
4+	15345	35442	46153	85354	11226	11431	21003	35731	48478	47972	46516	58757	96053	89422	124243	81855
5+	7631	27415	14617	29273	5603	5260	10816	18672	14273	31377	36256	28004	30077	40971	69385	54377
6+	3889	11612	8805	6789	3586	2301	4195	7319	4812	13302	18891	15947	15253	16163	32214	27605

TABLE 12: 4VSW COD RESEARCH SURVEY RESULTS CALCULATED ASSUMING THE DELTA DISTRIBUTION, A) MEAN CATCH PER TOW, B) VARIANCE, C)CV.

A.	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
0	0.035	0.013	0.000	0.063	0.326	0.025	0.000	0.033	0.062	0.520	0.018	0.027	0.062	0.020	0.070	0.012
1	0.530	0.550	2.342	5.684	1.801	1.286	0.756	0.296	1.122	0.435	0.246	2.078	0.915	10.404	0.429	1.287
2	6.854	2.787	3.528	43.978	9.845	3.541	5.055	3.699	4.501	4.039	2.579	5.380	51.939	18.091	7.718	1.660
3	1.878	12.827	2.780	32.826	6.743	5.508	5.846	9.607	11.200	10.753	6.842	5.678	33.196	29.278	10.801	8.312
4	2.572	2.897	6.353	16.494	2.046	2.908	3.760	6.289	12.882	6.407	3.902	12.063	12.737	12.632	16.522	10.636
5	1.325	5.628	1.198	7.870	0.637	1.064	2.623	3.675	3.387	7.957	6.972	4.946	4.174	9.325	17.213	9.763
6	0.445	2.077	1.295	0.670	0.716	0.238	0.498	1.495	1.260	3.616	4.824	3.842	2.519	3.814	5.155	4.951
7	0.549	1.241	0.388	1.050	0.110	0.318	0.236	0.358	0.321	0.981	1.799	2.182	1.379	0.917	3.526	2.467
8	0.173	0.529	0.188	0.340	0.121	0.082	0.478	0.317	0.066	0.362	0.430	0.573	0.615	0.539	0.397	0.965
9	0.037	0.229	0.177	0.154	0.075	0.155	0.000	0.087	0.032	0.147	0.118	0.191	0.162	0.137	0.292	0.478
10	0.089	0.025	0.055	0.185	0.058	0.008	0.350	0.000	0.028	0.030	0.095	0.233	0.153	0.076	0.096	0.118
11	0.075	0.049	0.000	0.059	0.023	0.000	0.014	0.058	0.000	0.016	0.033	0.059	0.079	0.022	0.234	0.109
12	0.036	0.021	0.000	0.000	0.021	0.024	0.000	0.022	0.000	0.002	0.000	0.009	0.000	0.010	0.006	0.070
13+	0.149	0.109	0.000	0.088	0.020	0.027	0.089	0.032	0.047	0.010	0.000	0.022	0.030	0.010	0.067	0.013
0+	14.747	28.982	18.304	109.461	22.542	15.184	19.705	25.968	34.908	35.275	27.858	37.283	107.960	85.275	62.526	40.841
5+	2.878	9.908	3.301	10.416	1.781	1.916	4.288	6.044	5.141	13.121	14.271	12.057	9.111	14.850	26.986	18.934

B.	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
0	0.000	0.000	0.000	0.001	0.047	0.001	0.000	0.000	0.001	0.140	0.000	0.000	0.001	0.000	0.001	0.000
1	0.022	0.040	2.801	24.485	0.553	0.315	0.071	0.006	0.033	0.010	0.005	1.586	0.090	79.770	0.066	0.732
2	5.609	0.703	1.146	1622.328	20.412	1.781	1.621	0.469	3.918	1.623	1.020	6.021	1865.335	115.783	6.691	0.277
3	0.325	56.706	1.844	418.866	5.526	5.430	1.198	3.849	20.337	39.008	6.048	3.347	444.454	120.404	25.324	2.733
4	0.833	1.823	17.409	118.836	0.173	1.671	1.163	2.906	9.535	2.347	1.155	26.623	37.504	14.766	48.623	9.806
5	0.319	10.824	0.292	31.983	0.023	0.043	0.763	1.541	0.992	5.229	4.138	4.413	1.605	14.590	117.339	10.428
6	0.028	1.292	0.650	0.268	0.038	0.003	0.031	0.245	0.048	0.748	3.090	2.448	0.588	0.961	4.817	2.101
7	0.049	0.416	0.061	0.499	0.001	0.009	0.004	0.019	0.001	0.029	0.285	1.044	0.185	0.032	2.621	0.294
8	0.003	0.033	0.014	0.015	0.003	0.001	0.081	0.017	0.001	0.004	0.019	0.041	0.051	0.029	0.017	0.032
9	0.001	0.025	0.013	0.015	0.001	0.004	0.000	0.001	0.000	0.001	0.003	0.008	0.004	0.001	0.017	0.010
10	0.002	0.000	0.002	0.010	0.001	0.000	0.064	0.000	0.000	0.000	0.003	0.015	0.006	0.001	0.001	0.001
11	0.004	0.001	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.002	0.000	0.028	0.002
12	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13+	0.006	0.003	0.000	0.002	0.000	0.001	0.006	0.001	0.002	0.000	0.000	0.000	0.001	0.000	0.002	0.000

C.	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
0	0.000	0.000	0.000	0.502	0.665	1.265	0.000	0.000	0.510	0.720	0.000	0.000	0.510	0.000	0.452	0.000
1	0.280	0.364	0.715	0.871	0.413	0.436	0.352	0.262	0.162	0.230	0.287	0.606	0.328	0.858	0.599	0.665
2	0.346	0.301	0.303	0.916	0.459	0.377	0.252	0.185	0.440	0.315	0.392	0.456	0.832	0.595	0.335	0.317
3	0.304	0.587	0.488	0.623	0.349	0.423	0.187	0.204	0.403	0.581	0.359	0.322	0.635	0.375	0.466	0.199
4	0.355	0.466	0.657	0.661	0.203	0.445	0.287	0.271	0.240	0.239	0.275	0.428	0.481	0.304	0.422	0.294
5	0.426	0.585	0.451	0.719	0.238	0.195	0.333	0.338	0.294	0.287	0.292	0.425	0.304	0.410	0.629	0.331
6	0.376	0.547	0.623	0.773	0.272	0.230	0.354	0.331	0.174	0.239	0.364	0.407	0.304	0.257	0.426	0.293
7	0.403	0.520	0.637	0.673	0.287	0.298	0.268	0.385	0.099	0.174	0.297	0.468	0.312	0.195	0.459	0.220
8	0.517	0.343	0.629	0.360	0.453	0.386	0.595	0.411	0.479	0.175	0.321	0.353	0.367	0.316	0.328	0.185
9	0.855	0.690	0.644	0.795	0.422	0.408	0.000	0.363	0.000	0.215	0.464	0.468	0.390	0.231	0.447	0.209
10	0.502	0.000	0.813	0.541	0.545	0.000	0.723	0.000	0.000	0.000	0.577	0.526	0.506	0.416	0.329	0.268
11	0.843	0.645	0.000	0.536	1.375	0.000	0.000	0.000	0.000	0.000	0.958	0.758	0.566	0.000	0.715	0.410
12	0.878	0.000	0.000	0.000	0.000	1.318	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13+	0.520	0.502	0.000	0.508	0.000	1.171	0.870	0.988	0.951	0.000	0.000	0.000	1.054	0.000	0.667	0.000

Table 13. Analysis of variance from the multiplicative analysis of 4VsW cod catch rates.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R............. .758
MULTIPLE R SQUARED..... .574

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	3.858E0002	3.858E0002	
REGRESSION	44	4.664E0002	1.060E0001	41.374
TYPE 1	12	2.358E0002	1.965E0001	76.679
TYPE 2	1	5.487E0000	5.487E0000	21.415
TYPE 3	11	2.503E0001	2.276E0000	8.882
TYPE 4	20	1.148E0002	5.741E0000	22.405
RESIDUALS	1351	3.461E0002	2.562E¯001	
TOTAL	1396	1.198E0003		

Table 14. Regression coefficients from the multiplicative analysis of 4VsW cod catch rates.

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	3	INTERCEPT	0.289	0.144	1396
2	1				
3	1				
4	1				
1	4	1	¯0.558	0.093	43
	5	2	0.007	0.071	95
	6	3	0.207	0.069	95
	7	4	0.426	0.061	141
	8	5	¯0.602	0.060	196
	9	6	¯0.552	0.062	165
	10	7	¯0.549	0.084	53
	11	8	¯0.121	0.083	57
	12	9	0.193	0.103	33
	13	10	0.260	0.083	57
	15	11	0.534	0.067	232
	16	12	0.916	0.075	93
2	2	13	¯0.139	0.030	674
3	2	14	¯0.062	0.076	114
	3	15	¯0.116	0.072	154
	4	16	¯0.294	0.072	153
	5	17	¯0.330	0.073	142
	6	18	¯0.384	0.077	110
	7	19	¯0.447	0.082	87
	8	20	¯0.366	0.078	107
	9	21	¯0.326	0.077	112
	10	22	¯0.326	0.075	130
	11	23	¯0.093	0.076	118
	12	24	¯0.053	0.079	93

LEGEND

Category		Code			
1	Gear	3	OTB1	TC4	Maritime
		4	OTB2	TC2	Maritime
		5	OTB2	TC3	Maritime
		6	OTB2	TC4	Maritime
		7	OTB2	TC5	Maritime
		8	LL	TC2	Maritime
		9	LL	TC3	Maritime
		10	LL	TC4	Maritime
		11	OTB1	TC4	Newfoundland
		12	OTB2	TC4	Newfoundland

Category		Code			
1	Gear	13	OTB2	TC5	Newfoundland
		15	PT	TC4	Spain
		16	PT	TC5	Spain
2	Area	1	4Vs		
		2	4W		
3	Month	1-12	January-December		
4	Year	1	1965		

Table 15. Predicted catch rates for 4VsW cod.

PREDICTED CATCH RATE

STANDARDS USED VARIABLE NUMBERS: 3 1 1

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	CATCH RATE S.E.	EFFORT
1965	70988	0.554	1.502	0.215	47247
1966	68270	0.632	1.490	0.230	45822
1967	54157	0.366	0.959	0.117	56452
1968	80425	0.645	1.239	0.162	64921
1969	50157	0.636	1.293	0.165	38805
1970	57427	0.673	1.161	0.151	49470
1971	52563	0.585	0.912	0.098	57618
1972	61645	0.459	0.807	0.081	76435
1973	54093	0.595	0.782	0.075	69201
1974	43741	0.719	0.570	0.050	76760
1975	32517	0.586	0.443	0.041	73353
1976	24407	0.599	0.555	0.049	44010
1977	10390	0.389	0.599	0.058	17335
1978	25405	0.068	0.816	0.091	31143
1979	40030	0.122	0.888	0.101	45086
1980	49252	0.675	0.949	0.082	51876
1981	53718	0.675	0.944	0.080	56883
1982	55754	0.792	1.035	0.087	53857
1983	52332	0.725	0.951	0.082	55004
1984	52130	0.725	1.122	0.100	46479
1985	56090	0.352	1.610	0.151	34841

AVERAGE C.V. FOR THE MEAN: .106

Table 16. Partial recruitment estimates for 4VsW cod.

AGE	PR 84	PR 82-84	PR 79-81	PR 70-78
3	.07	.13	.07	.21
4	.34	.51	.34	.54
5	.65	.87	.77	.91
6	.85	1.01	1.00	1.00
7	1.00	1.11	1.00	1.00
8	1.00	1.03	.87	1.00
9	1.00	1.01	.63	1.00
10	1.00	.86	.45	1.00
11	1.00	1.06	.45	1.00

Table 17. Calibration results using delta mean 5+ catch per tow as dependent variable vs SPA 5+ mean population numbers, 1970 point not included. The results are the correlation coefficient (r), intercept (a), slope (b), student T for the intercept (T), and the sum of standardized residuals (RES).

	F_t				
	.20	.25	.30	.35	.40
r	.86	.87	.86	.85	.83
a	1.31	.02	-1.13	-2.06	-2.76
b x 10^{-4}	1.69	2.15	2.57	2.95	3.25
T	.77	.01	-.55	-.89	-1.06
Res	5.76	5.76	5.70	5.68	5.78

Table 18. Calibration results using SPA fishable biomass as dependent variable vs CPUE. See Table 17 for legend.

	F_t					
	.20	.25	.30	.35	.40	.45
r	.83	.84	.84	.83	.81	.79
a x 10^{-4}	-7.66	-4.59	2.54	-1.07	.02	.87
b	234	186	154	131	114	101
T	-2.01	-1.55	-1.03	-.49	.01	.45
Res	9.4	10.4	11.1	11.4	10.6	11.1

Table 19. 4VsW cod beginning of the year population at age with 1985 terminal F of 0.30.

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	94640	96106	73825	65270	79307	86774	74343	74890	118900	113466	133893	106765	65252	63495	91000	90996
2	87620	76315	76594	58287	52156	63590	69423	60208	61313	97187	92887	109594	87409	53419	51986	74505
3	51826	63927	48711	46660	36735	35055	43034	53164	49273	50060	79496	75912	89413	71429	43736	42560
4	54245	34391	40955	27008	24737	18417	20118	31987	43178	39433	39512	63246	58766	70944	55723	35427
5	45685	31019	19882	21441	15320	11253	11151	13112	25218	32048	26707	27718	42982	41178	50618	40003
6	19352	25032	17425	7536	8728	6091	5097	4770	9324	16466	17964	15431	16110	26185	27047	32963
7	6290	11737	11209	6322	2711	4643	2640	1990	3117	5425	9074	9146	8243	10069	16040	16613
8	2929	3393	4941	6072	2465	1365	1424	871	1176	1857	3390	4779	4782	4570	6490	9420
9	585	1712	1105	2309	1601	821	564	613	514	770	1185	1811	2596	2764	2838	4143
10	319	265	953	581	835	937	223	295	386	320	562	681	1127	1516	1741	1809
11	320	196	114	424	228	350	170	138	210	244	241	381	444	648	1034	1161
12	211	138	42	22	77	173	148	120	73	148	191	155	255	223	404	712
13	30	122	48	33	15	58	28	24	48	35	117	133	98	148	137	275
14	156	16	11	6	20	12	15	22	10	16	25	92	90	28	102	80
15	15	117	2	9	0	17	2	9	15	0	12	19	74	28	9	68
1+	364223	344486	295816	241979	224935	229557	228380	242214	312756	357475	405257	415862	377641	346644	348904	350736
2+	269583	248379	221991	176709	145629	142783	154037	167324	193856	244009	271364	309097	312389	283149	257903	259739
3+	181963	172064	145397	118422	93473	79193	84614	107116	132543	146822	178476	199503	224980	229729	205918	185235
4+	130137	108137	96685	71762	56738	44139	41580	53952	83271	96762	98980	123591	135567	158300	162182	142674
5+	75891	73746	55731	44754	32001	25722	21462	21964	40093	57329	59469	60345	76801	87357	106459	107247
6+	30206	42727	35849	23312	16681	14469	10311	8853	14875	25281	32762	32628	33819	46178	55841	67244

TABLE 20: 4VSW COD MEAN POPULATION BIOMASS AT AGE WITH 1985 TERMINAL F OF 0.30.

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	1703	860	3288	4677	9251	7778	6703	6788	21536	0	0	0	0	6906	0	0
2	11273	6763	10871	10271	14203	14214	17061	15276	34408	46664	47945	61084	46008	18882	26338	42878
3	19132	16509	16192	15546	16449	14256	21226	38878	41962	33879	56849	55789	64281	51073	28552	26989
4	37816	16945	24424	16286	17461	12888	15711	31031	46671	34617	38257	59756	53040	65172	47382	32336
5	51494	25222	16417	17115	15310	10415	10970	18555	34494	41362	32889	36215	53547	52073	58532	46674
6	33350	26839	20260	8117	13785	7720	6707	9169	17783	29648	28869	24452	30752	43462	40910	51387
7	13799	16416	20781	9338	5532	6728	4244	4907	8783	13548	20631	19953	17305	25286	30945	32566
8	8453	5404	10862	9727	5354	2828	3225	3101	5016	5550	10856	14097	14996	12830	17971	23500
9	1822	4158	3121	5130	5468	1748	1690	2033	2288	3152	4787	8219	11026	9689	8628	12822
10	1333	671	2952	1593	2944	2038	850	1334	2025	1906	3221	3969	6126	7259	7106	7266
11	1301	428	289	996	1236	1236	796	475	1406	1722	1474	2409	2803	3607	5898	5816
12	1089	405	217	102	479	479	431	385	474	1244	1630	1151	1793	1594	2716	3428
13	163	242	127	163	111	217	175	115	302	312	825	1303	642	1312	950	2153
14	1076	40	72	5	166	43	91	158	12	140	178	715	558	195	855	707
15	100	475	12	42	0	83	11	74	103	0	129	142	715	279	82	600
1+	183904	121378	129885	99108	107750	82670	89888	132279	217263	213743	248541	289255	303592	299620	276865	289122
2+	182201	120518	126598	94430	98499	74893	83186	125492	195727	213743	248541	289255	303592	292714	276865	289122
3+	170928	113755	115727	84160	84296	60679	66125	110216	161319	167079	200596	228171	257583	273832	250527	246244
4+	151796	97246	99535	68613	67847	46422	44899	71337	119358	133200	143747	172382	193302	222759	221976	219255
5+	113981	80301	75111	52328	50386	33534	29188	40306	72686	98583	105490	112626	140262	157587	174593	186919
6+	62487	55078	58694	35212	35077	23119	18218	21752	38193	57220	72601	76411	86715	105514	116062	140245

TABLE 21: 4VSW COD FISHING MORTALITY AT AGE WITH 1985 TERMINAL F OF 0.30.

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	0.015	0.027	0.036	0.024	0.021	0.023	0.011	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.115	0.249	0.296	0.262	0.197	0.190	0.067	0.000	0.003	0.001	0.002	0.004	0.002	0.000	0.000	0.000
3	0.210	0.245	0.390	0.435	0.490	0.355	0.097	0.008	0.023	0.037	0.029	0.056	0.031	0.048	0.011	0.004
4	0.359	0.348	0.447	0.367	0.588	0.302	0.228	0.038	0.098	0.190	0.155	0.186	0.156	0.138	0.131	0.075
5	0.402	0.377	0.770	0.699	0.722	0.592	0.649	0.141	0.226	0.379	0.349	0.343	0.296	0.220	0.229	0.261
6	0.300	0.603	0.814	0.822	0.431	0.636	0.740	0.225	0.342	0.396	0.475	0.427	0.270	0.290	0.287	0.300
7	0.417	0.665	0.413	0.742	0.486	0.982	0.909	0.326	0.318	0.270	0.441	0.449	0.390	0.239	0.332	0.300
8	0.337	0.922	0.561	1.133	0.899	0.684	0.643	0.327	0.223	0.249	0.427	0.410	0.348	0.277	0.249	0.300
9	0.591	0.386	0.443	0.817	0.335	1.105	0.447	0.262	0.275	0.115	0.353	0.274	0.338	0.262	0.250	0.300
10	0.287	0.645	0.609	0.733	0.670	1.505	0.279	0.140	0.260	0.081	0.190	0.229	0.354	0.183	0.206	0.300
11	0.642	1.342	1.455	1.509	0.075	0.660	0.154	0.434	0.147	0.046	0.242	0.199	0.490	0.273	0.173	0.300
12	0.348	0.862	0.054	0.165	0.075	1.624	1.606	0.710	0.550	0.037	0.163	0.259	0.344	0.285	0.183	0.300
13	0.410	2.197	1.954	0.272	0.000	1.145	0.040	0.693	0.909	0.134	0.038	0.192	1.039	0.179	0.332	0.300
14	0.089	1.743	0.000	7.427	0.000	1.634	0.344	0.163	7.679	0.071	0.046	0.024	0.979	0.976	0.205	0.300
15	0.338	0.648	0.643	0.914	0.521	0.890	0.802	0.286	0.338	0.344	0.449	0.415	0.328	0.273	0.289	0.300

Table 22. Catch at age in 1985 and projected to 1986-87 under 2 options:

a) F = .2 in both years
b) a catch of 48,000 t in 1986 and F = .2 in 1987

A.

	1985	1986	1987
1	0	0	0
2	4	2	2
3	154	147	147
4	2323	1535	2203
5	8353	3900	3918
6	7782	4160	3053
7	3922	3263	2789
8	2224	1661	2187
9	978	942	1113
10	427	414	631
11	274	181	278
12	168	116	121
13	65	71	78
14	19	28	48
15	16	8	18
1+	26709	16429	16587
2+	26709	16429	16587
3+	26705	16427	16585
4+	26551	16280	16437

B.

	1985	1986	1987
1	0	0	0
2	4	3	2
3	154	192	147
4	2323	1988	2202
5	8353	4962	3859
6	7782	5274	2896
7	3922	4137	2624
8	2224	2106	2058
9	978	1194	1048
10	427	525	594
11	274	229	261
12	168	147	114
13	65	90	73
14	19	35	45
15	16	10	17
1+	26709	20891	15941
2+	26709	20891	15941
3+	26705	20888	15938
4+	26551	20697	15791

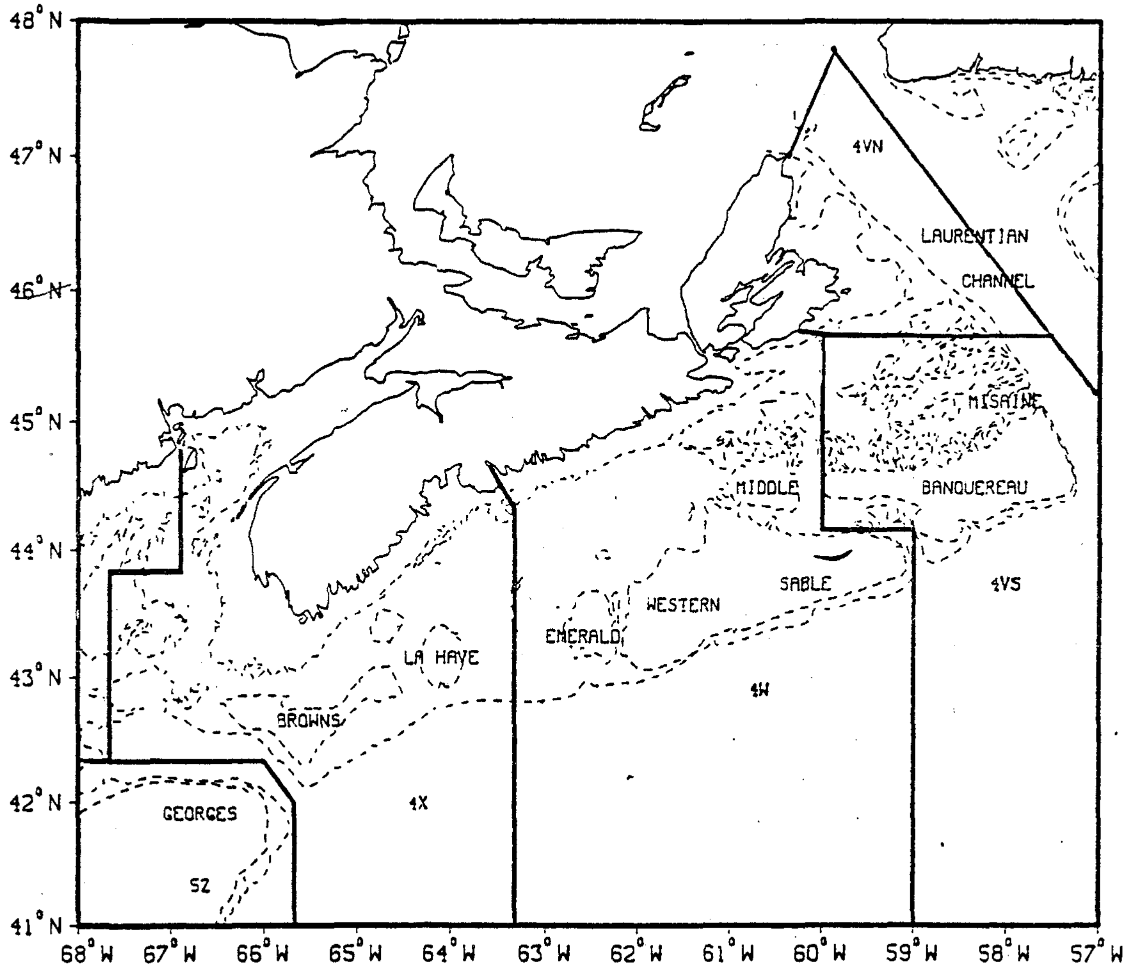


Figure 1. Map of the Scotian Shelf indicating common fishing banks and NAFO statistical areas.

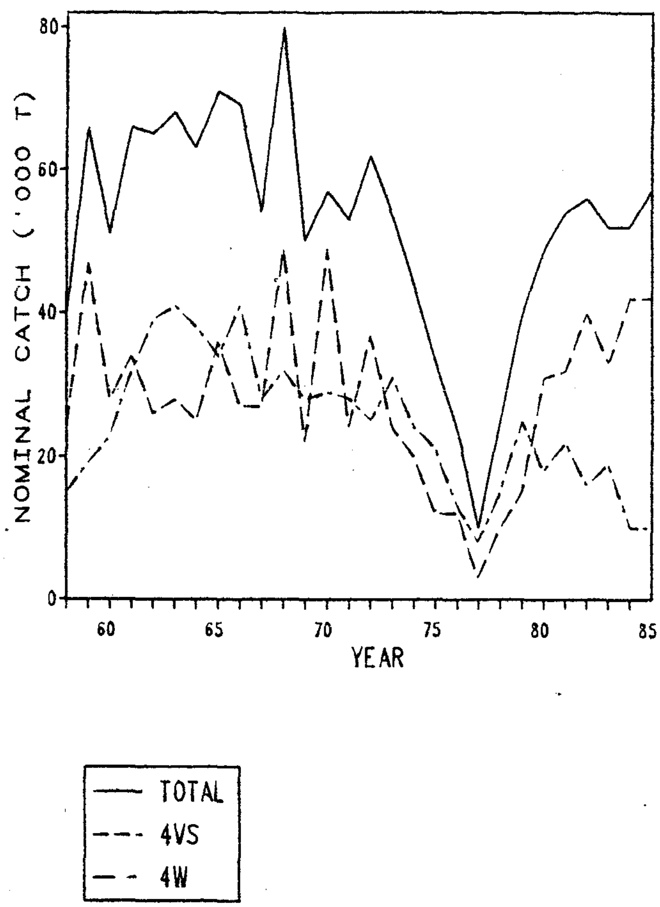


Figure 2. Total nominal catch and catch by Division for 4VsW cod, 1958-1985.

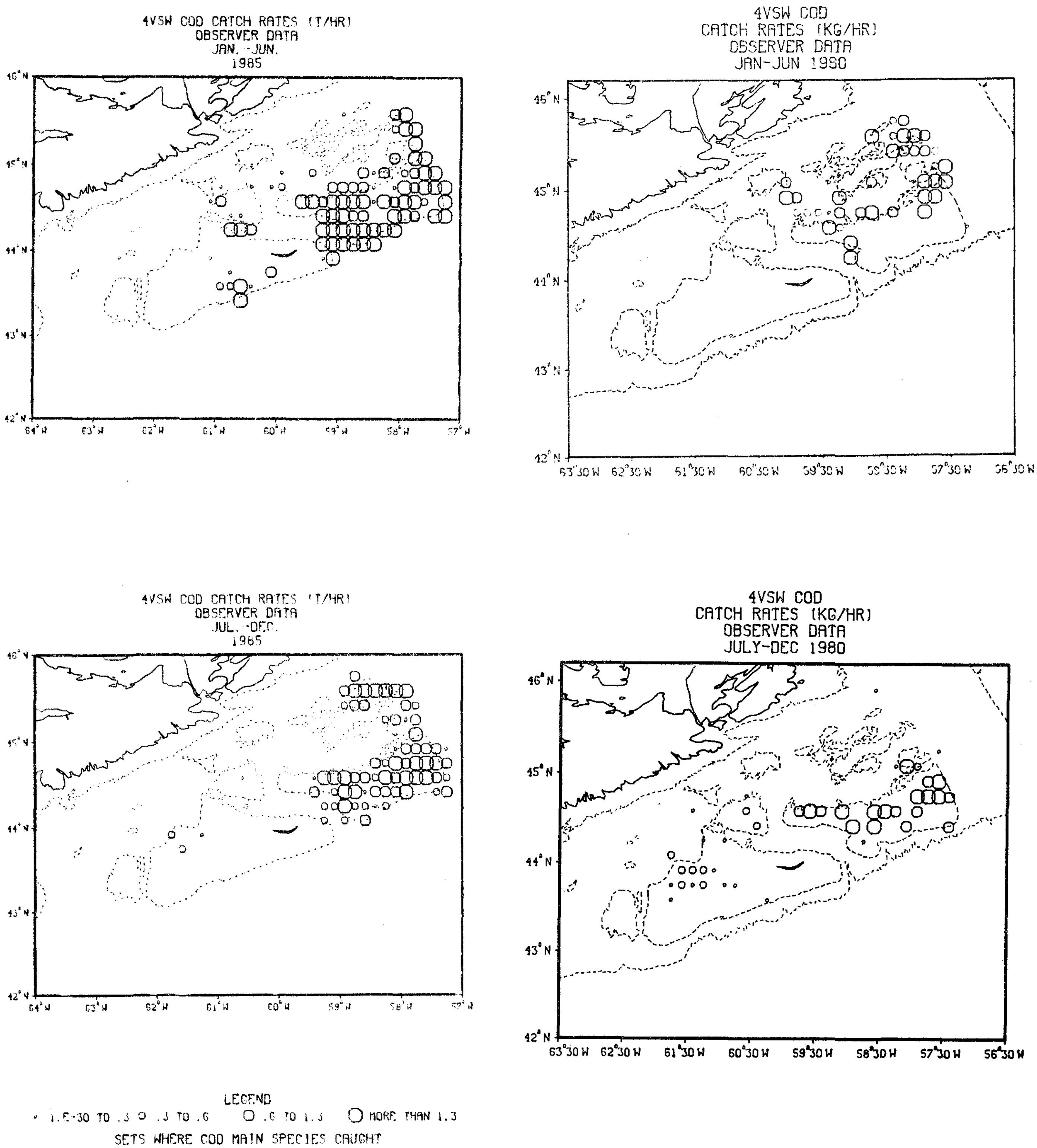


Figure 3. Distribution of catch per unit effort for 4VsW cod for 1980 and 1985. Data from the Scotia Fundy Region Observer Program.

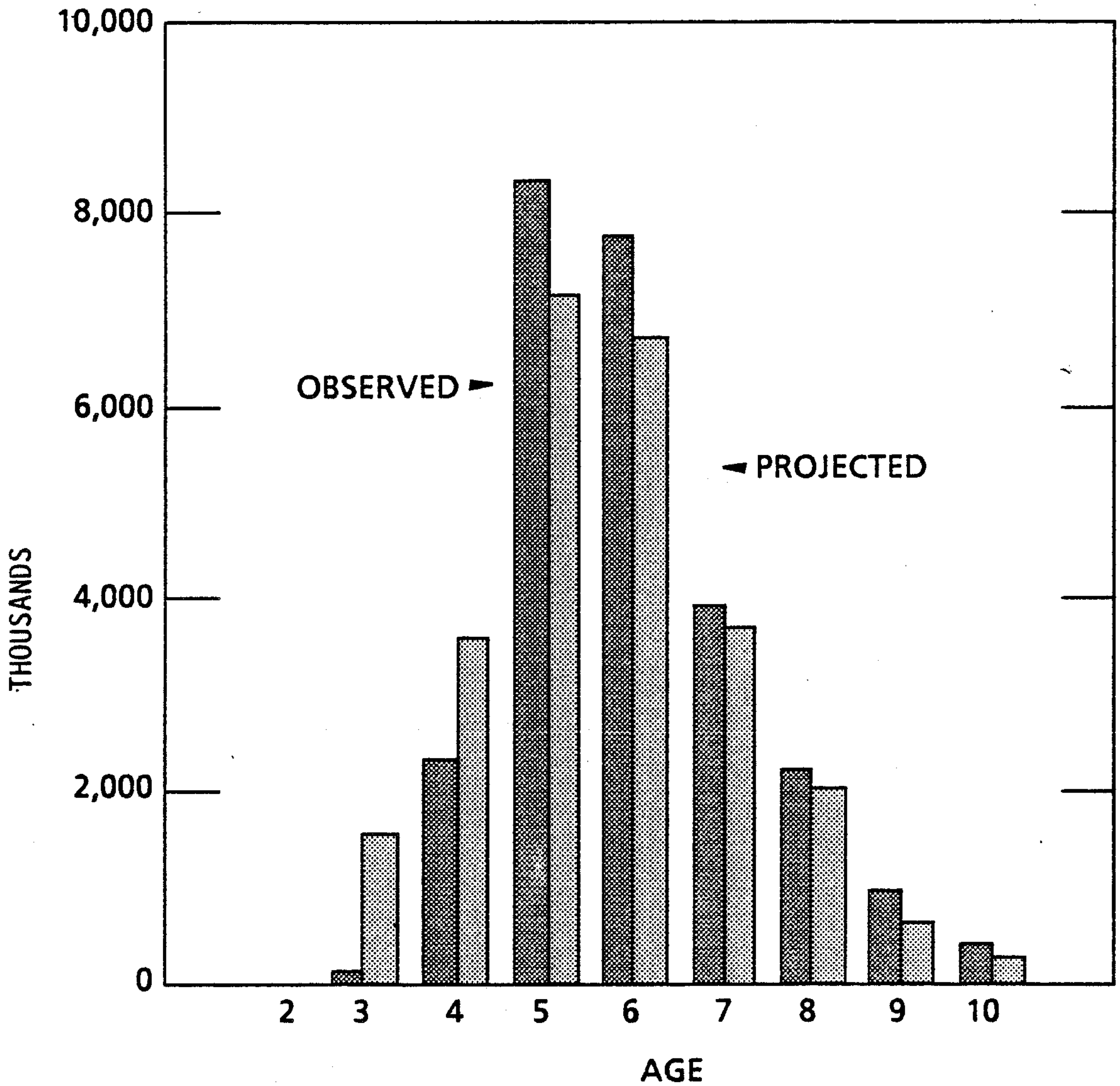


Figure 4. Comparison of observed and projected 1985 catch at age ('000) for 4VsW cod.

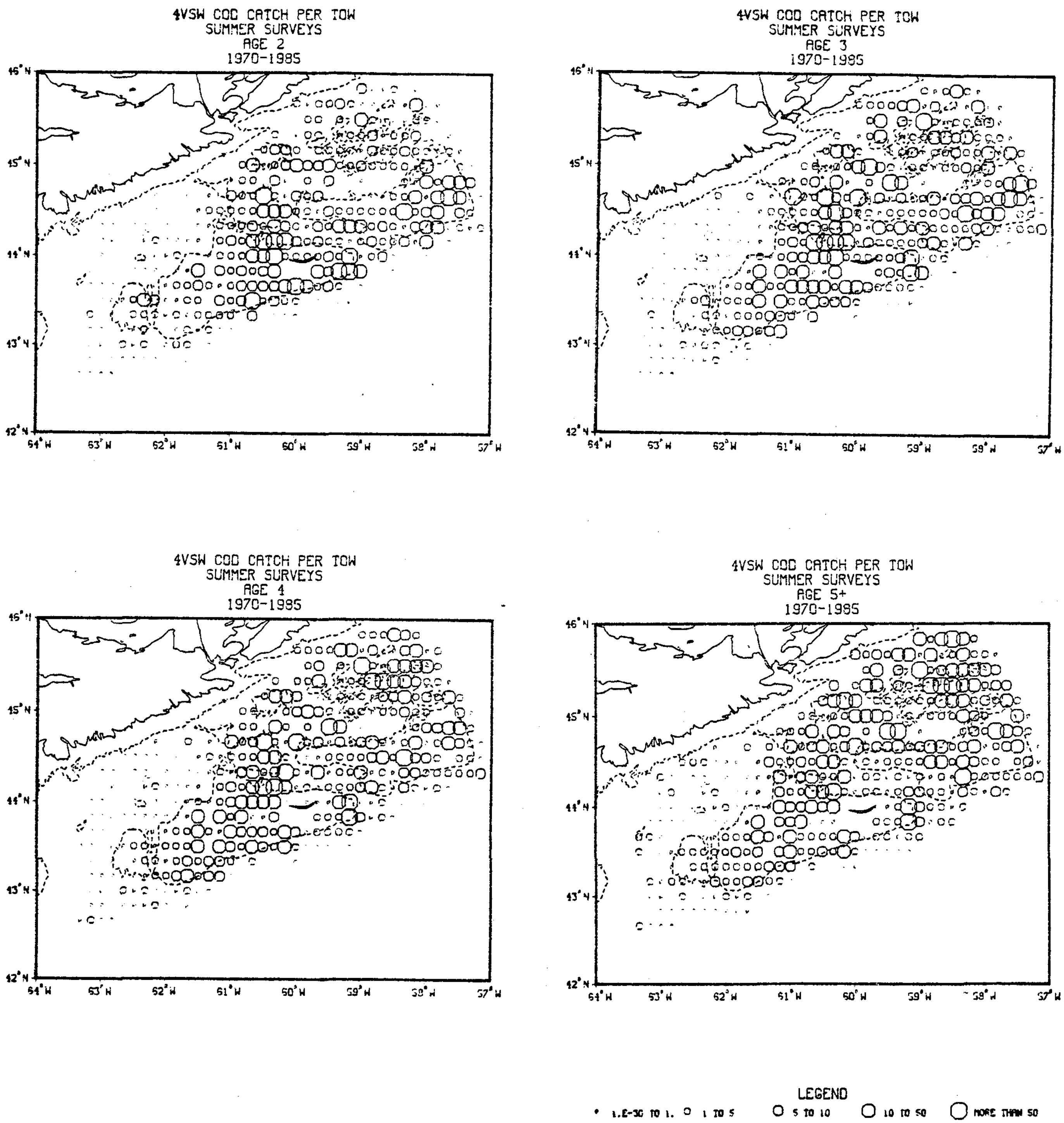


Figure 5. Summer research survey mean catch per tow at age aggregated by 10' square for 4VsW cod.

A. B.

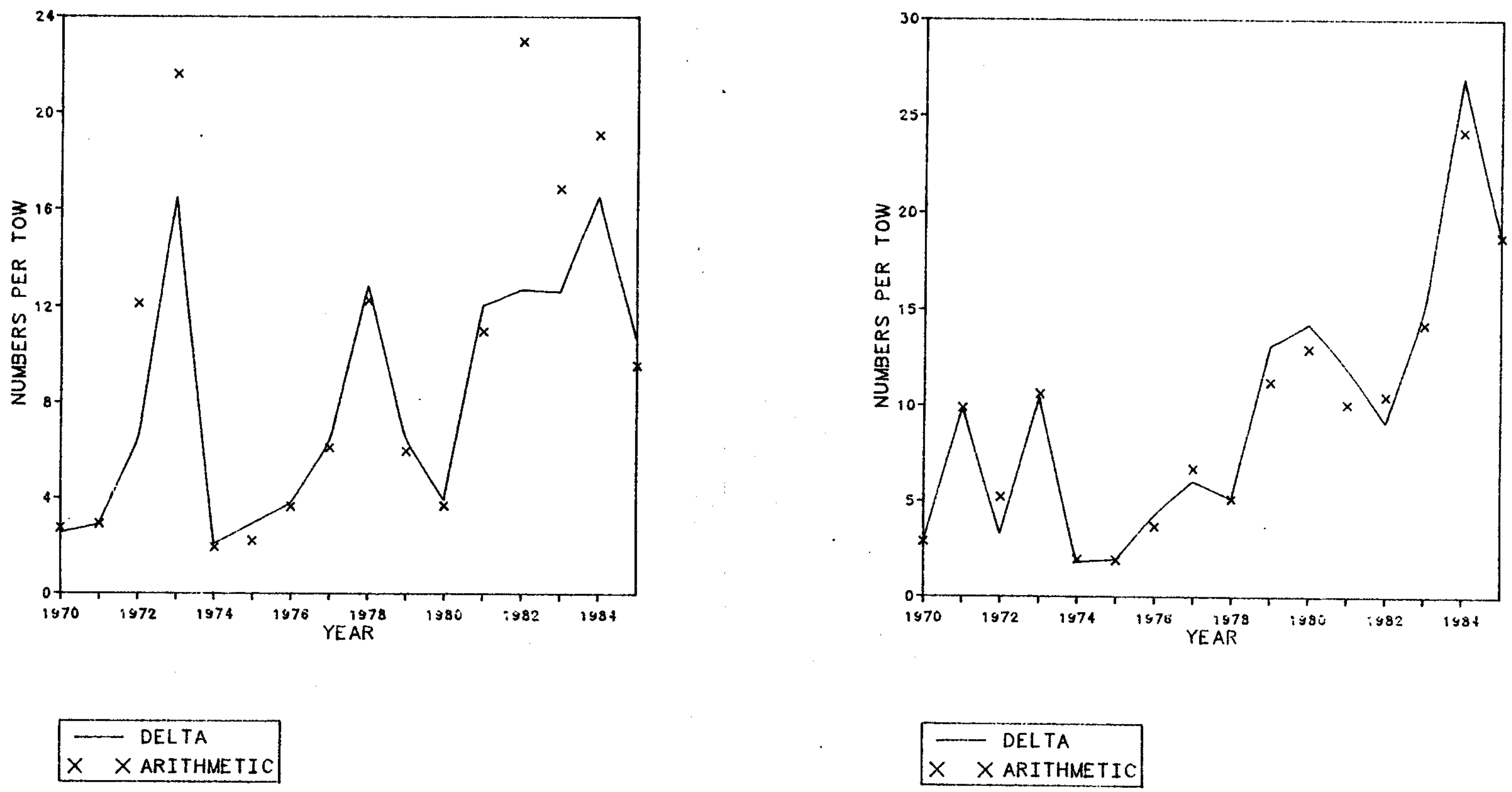


Figure 6. Comparison of summer research survey arithmetic and delta mean catches per tow for a) age 4 and b) age 5+.

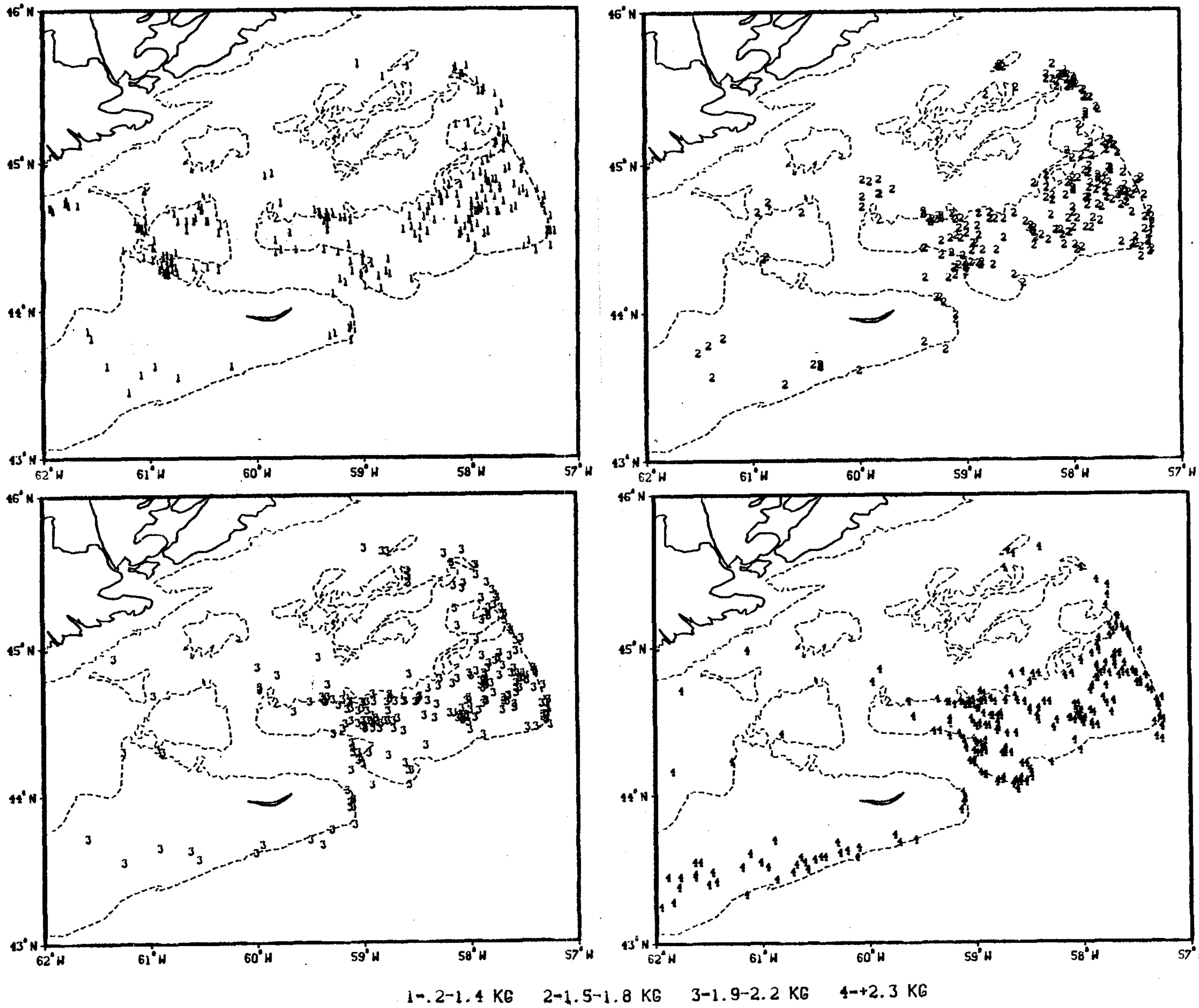


Figure 7. Commercial sample mean fish weight from the Scotia-Fundy Region Observer Program.

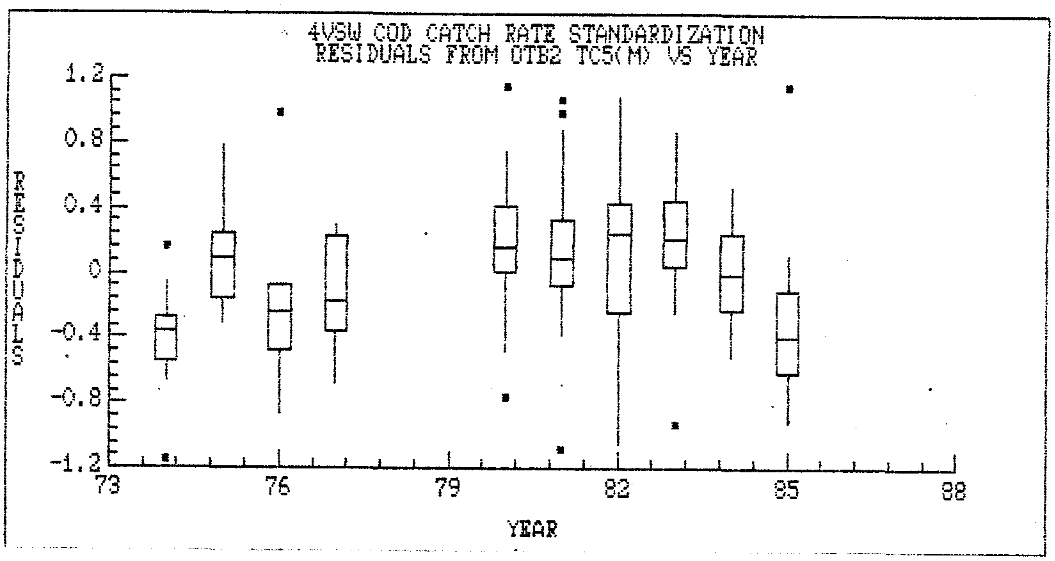
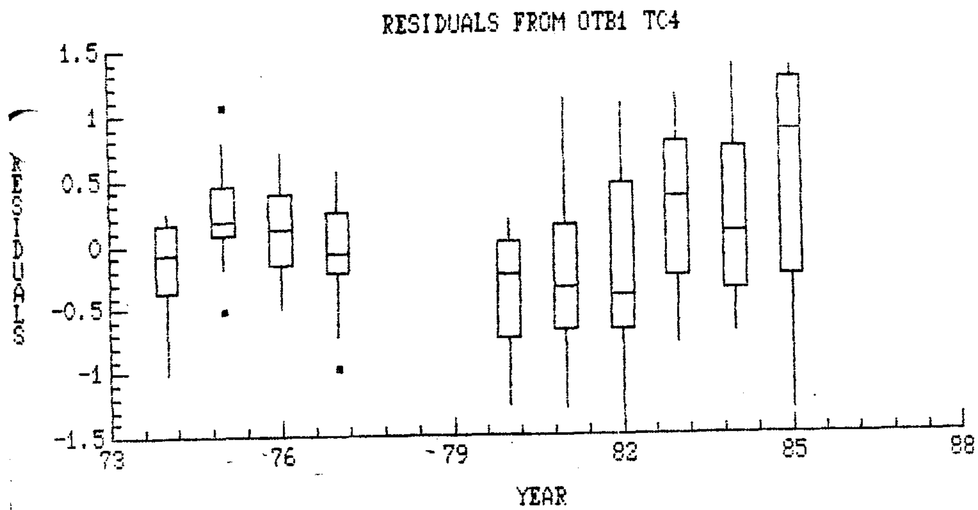


Figure 8. Residuals vs year for stern otter trawlers (M) TC5 from the initial multiplicative analysis.



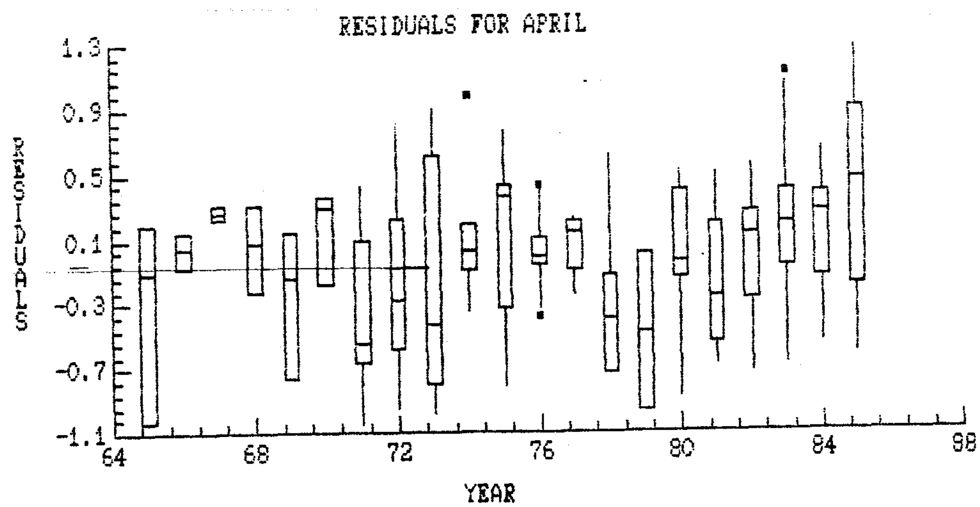


Figure 9. Residual distributions by year for side otter trawlers (OTB1) and the month of April from the final catch rate standardization.

Figure 10. Trend in standardized catch rate with 90% confidence intervals.

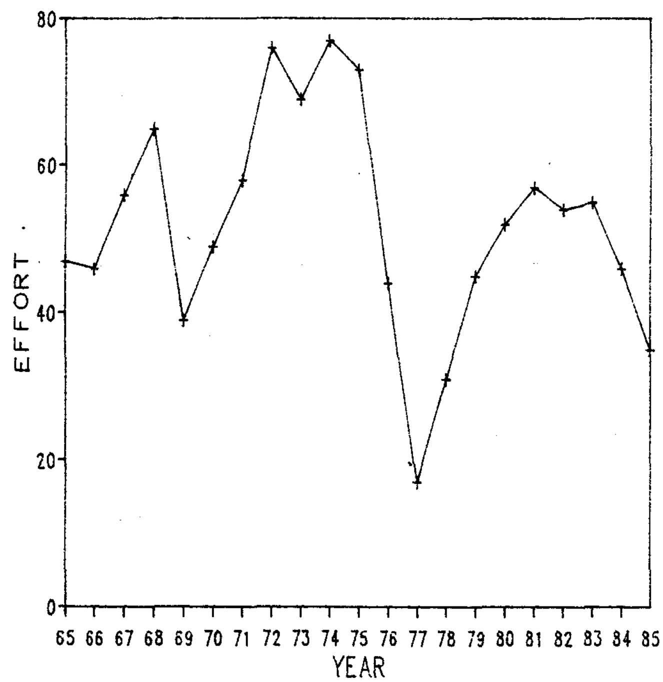
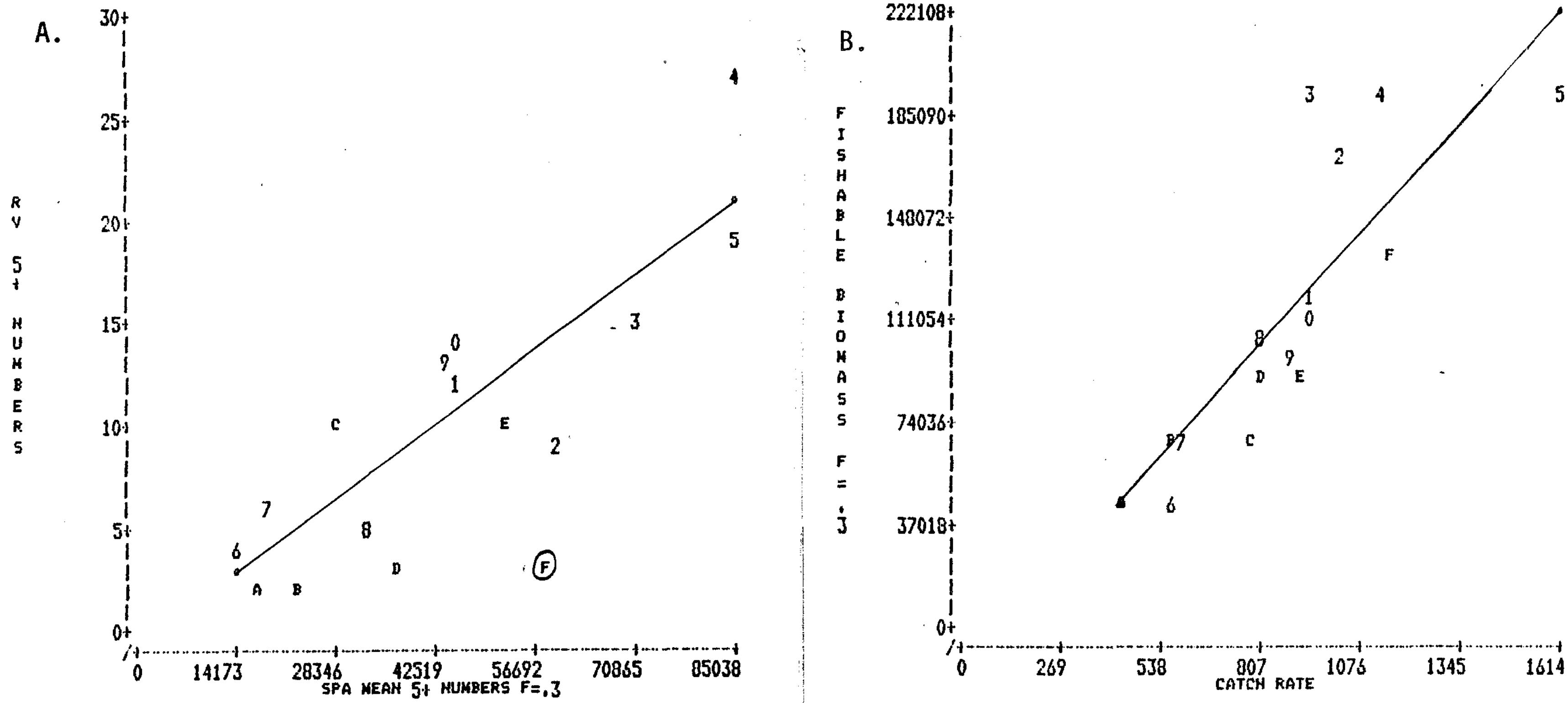


Figure 11. Trend in standardized effort.



S	YEAR	RESIDUALS	IND	DEP
F	1970	1.000	57955	3
E	1971	-0.692	52705	10
D	1972	-1.414	37267	3
C	1973	1.152	28509	10
B	1974	-0.762	22113	2
A	1975	-0.356	16872	2
6	1976	0.478	14255	4
7	1977	0.680	18213	6
8	1978	-0.548	32138	5
9	1979	0.808	43909	13
0	1980	1.066	44716	14
1	1981	0.382	45812	12
2	1982	-1.440	60214	9
3	1983	-0.508	70428	15
4	1984	1.707	85035	27
5	1985	-0.473	84671	19

S	YEAR	RESIDUALS	IND	DEP
F	1970	-0.589	1161	135924
E	1971	-0.781	912	92078
D	1972	-0.249	807	91429
C	1973	-1.059	782	63976
B	1974	0.036	570	63290
A	1975	0.040	443	43865
6	1976	-0.601	555	42431
7	1977	-0.101	599	63759
8	1978	0.133	816	103933
9	1979	-0.429	888	98622
0	1980	-0.440	949	107691
1	1981	-0.047	944	118349
2	1982	1.220	1035	169245
3	1983	2.413	951	191055
4	1984	1.581	1122	193133
5	1985	-1.129	1610	189237

Figure 12. Calibration plots for 4VsW cod.
a) Research survey 5+ mean catch per tow (Delta) vs SPA mean 5+ population (1970 point excluded)
b) Fishable biomass vs standardized catch rate.

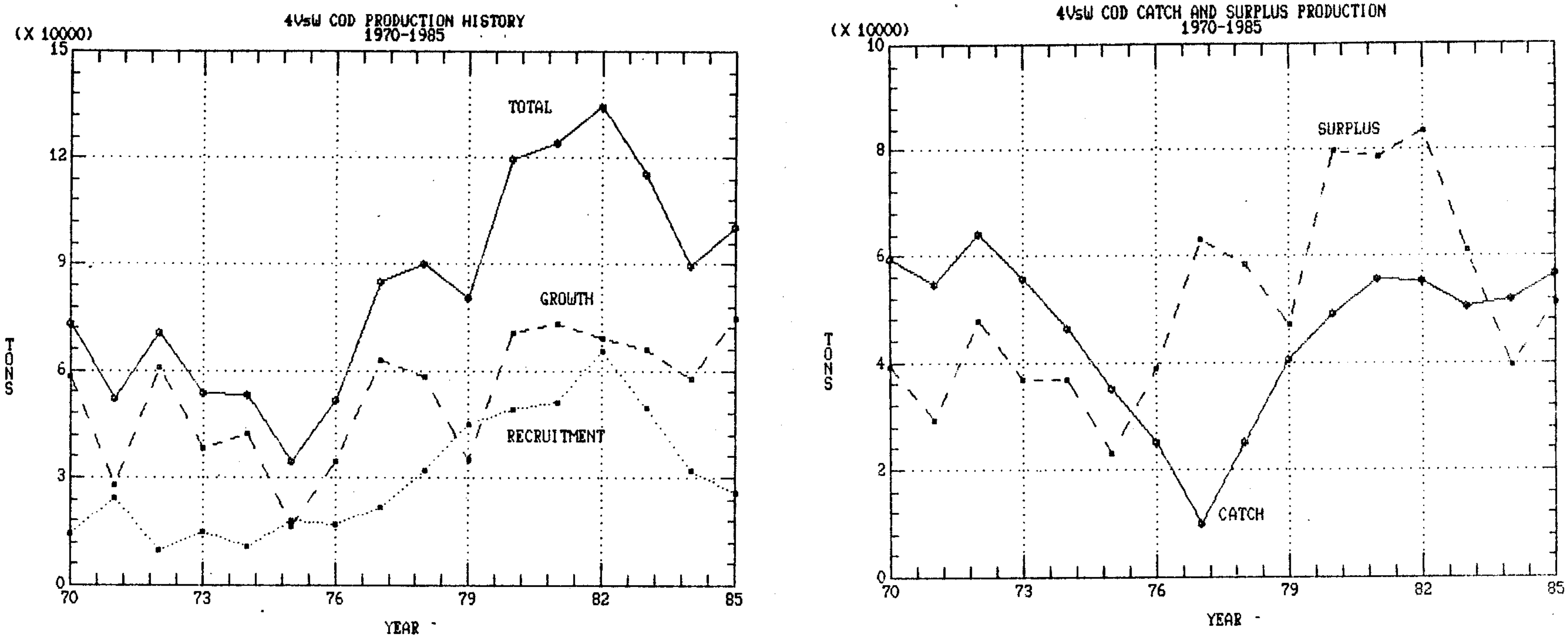


Figure 13. Summary of the components of production for 4VsW cod for the period 1970-85.